

Figure 1 shows graphs which compare the present battery A to comparative batteries in terms of capacity retention;

Figure 2 shows graphs which compare the battery A to the batteries B1 - B4 in terms of capacity retention;

5 Figure 3 shows graphs which compare the battery A to the batteries C1 - C8 in terms of capacity retention;

Figure 4 shows graphs which compare the present batteries A and D to comparative batteries in terms of capacity retention;

10 Figure 5 shows graphs which compare the battery D to the batteries E1 - E4 in terms of capacity retention;

Figure 6 shows graphs which compare the battery D to the batteries F1 - F4 in terms of capacity retention; and

15 Figure 7 shows graphs which compare the battery D to the batteries G1 - G4 in terms of capacity retention.

#### **BEST MODES FOR CARRYING OUT THE INVENTION**

The present invention is below described in more detail by way of examples. It will be recognized that the  
20 following examples merely illustrate the practice of the present invention but are not intended to be limiting thereof. Suitable changes and modifications can be effected without departing from the scope of the present invention.

The following Experiments 1 - 3 are directed to show  
25 examples in accordance with the first aspect of the present

invention.

## EXPERIMENT 1

In this experiment 1, batteries were constructed using various types of positive electrode materials and their performance characteristics were compared.

### (EXAMPLE)

Fabrication of a positive electrode is first described. Lithium hydroxide ( $\text{LiOH}$ ), manganese nitrate ( $\text{Mn}(\text{NO}_3)_2$ ) and aluminum nitrate ( $\text{Al}(\text{NO}_3)_3$ ) were blended in the ratio by mole of Li to Mn to Al of 1:1.95:0.05. The blend was heat treated in the atmosphere at  $800^\circ\text{C}$  for 20 hours and then subjected to size reduction to obtain a lithium-manganese complex oxide (first oxide) having a mean particle diameter of  $15\text{ }\mu\text{m}$  and represented by the compositional formula  $\text{LiMn}_{1.95}\text{Al}_{0.05}\text{O}_4$ . This first oxide had a spinel structure.

Also,  $\text{LiOH}$ , nickel nitrate ( $\text{Ni}(\text{NO}_3)_2$ ), cobalt nitrate ( $\text{Co}(\text{NO}_3)_2$ ) and manganese nitrate ( $\text{Mn}(\text{NO}_3)_3$ ) were blended in the ratio by mole of Li to Ni to Co to Mn of 1:0.6:0.3:0.1. The blend was heat treated in oxygen atmosphere at  $750^\circ\text{C}$  for 20 hours and then subjected to size reduction to obtain a lithium-nickel-cobalt complex oxide (second oxide) having a mean particle diameter of  $10\text{ }\mu\text{m}$  and represented by the compositional formula  $\text{LiNi}_{0.6}\text{Co}_{0.3}\text{Mn}_{0.1}\text{O}_2$ .

The first and second oxides such obtained were mixed in the ratio by weight of 1:1 to prepare a positive electrode

material (positive active material).

90 parts by weight of this powder-form positive active material, 5 parts by weight of artificial graphite powder and an N-methyl-2-pyrrolidone (NMP) solution containing 5 parts by weight of polyvinylidene fluoride were mixed to prepare a slurry. This slurry was applied to opposite sides of an aluminum foil by a doctor blade technique to form active material layers. Subsequent vacuum drying at 150 °C for 2 hours resulted in the fabrication of a positive electrode.

Then, 95 parts by weight of natural graphite and an NMP solution containing 5 parts by weight of polyvinylidene fluoride were mixed to prepare a carbon slurry. This carbon slurry was applied to opposite sides of a copper foil by a doctor blade technique to form carbon layers. Subsequent vacuum drying at 150 °C for 2 hours resulted in the fabrication of a negative electrode.

1 mole/liter of LiPF<sub>6</sub> was dissolved in a mixed solvent containing ethylene carbonate and dimethyl carbonate in a ratio by volume of 1:1 to prepare a nonaqueous electrolyte solution.

The above positive electrode, negative electrode and nonaqueous electrolyte solution were used to construct a battery A of the present invention in the form of an AA-size nonaqueous electrolyte secondary battery (battery size: 14